U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE LARAMIE AREA, WYOMING.

BY

N. P. NEILL AND PARTY.

[Advance Sheets—Field Operations of the Bureau of Soils, 1903.]

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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized into the Bureau of Soils.]

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SOIL SURVEY OF THE LARAMIE AREA, WYOMING.

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LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed lies in the south central part of Albany County, extending in a southeast-northwest direction along the Laramie River for a distance of about 40 miles. It is bounded on the north by the township line 6 miles north of the fourth standard parallel north,

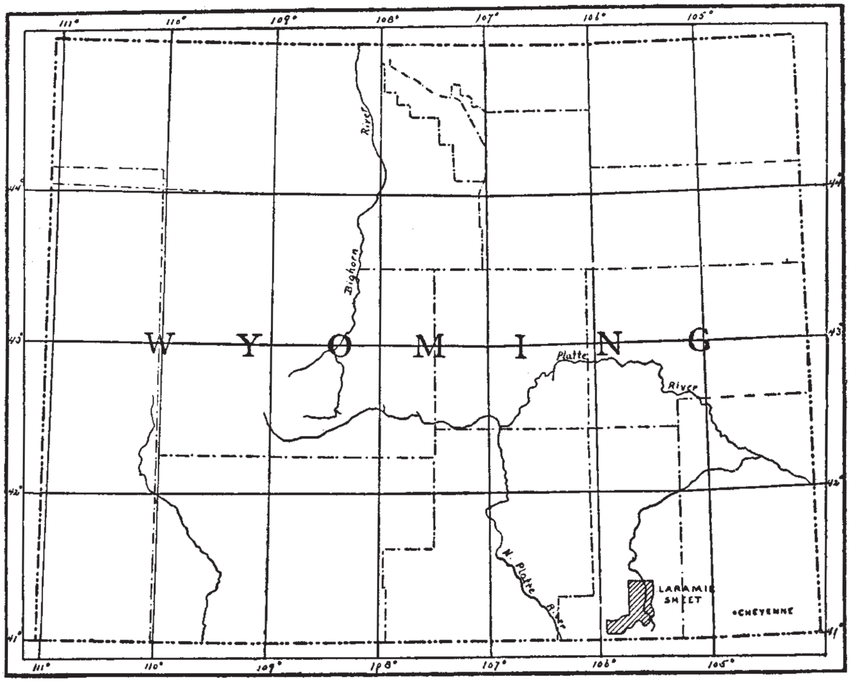

FIG. 1.—Sketch map showing position of the Laramie area, Wyoming.

and on the south by the foothills of Jelm Mountains and Laramie Hills. The eastern boundary of the area is marked by the ninth guide meridian west and the foothills of the Laramie Range. The western boundary is marked by a line drawn south from the northwest corner of T. 17 N., R. 74 W., to the west center of T. 15 N., R. 74 W., and thence southwes. to the northeast corner of T. 14 N., R. 76 W.

Sheep and Jelm mountains form the extreme western boundary of the area. The area is about 8 miles wide, and includes within its boundaries approximately 309 square miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The Territory of Wyoming was formed by act of Congress on July 25, 1868, out of parts of the Territories of Dakota, Utah, and Idaho. Little is known of the history of Wyoming prior to 1840.

In 1868 the Union Pacific Railroad was completed. This really marked the beginning of the development of this area. It was in April of that year that the present city of Laramie was laid out by the railroad company. It was incorporated in 1873, and reincorporated in 1884. It is the county seat of Albany County, and in 1900, according to the Twelfth Census, had a population of 8,207. Situated on the Union Pacific Railroad, it affords an excellent shipping point for live stock, the principal product of the country.

Following the overthrow of the Indians the stock industry developed rapidly. Texas steers brought into Wyoming were fed on the range with profit. The gain in this case resulted simply from an increase in flesh. Later cows were brought into the Territory for breeding purposes, high-grade bulls were introduced, and owners who did not wish their bulls to roam with other than their own stock fenced in large tracts of land for range purposes. These fences were usually constructed of barbed wire. Later, land was taken up according to the United States land laws, fenced, and devoted entirely to stock raising. The stock was fed on the native grasses, which possess a high nutritive value.

Subsequently the low price of cattle caused much dissatisfaction among stockmen. This had a tendency to reduce the number of cattle raised in some places, while in others stock was held for higher prices. The low price of cattle stimulated the production of horses, which became quite profitable on account of the increased demand due to street railway building and city traffic. In more recent years the introduction of electric cars has decreased the demand for horses, and more attention is being paid to cattle raising.

The sheep industry was slow to develop. For a long time the low prices of wool prevented the raising of sheep with any great profit. The industry, however, has gradually increased until the outlook for sheep raising is promising.

Until very recently the grazing of cattle, horses, and sheep was the only industry of the area, and little attempt had been made to cultivate the soils. Both in the valley and on the uplands the soils are productive and, with irrigation, capable of forming the basis of a paying agriculture.

CLIMATE.

The climate of the Laramie area is essentially arid. The great distance from the sea, the effect of the mountains upon rainfall, and the prevalence of sunshine all contribute to make this a dry region. The air is dry and pure and possesses remarkable curative powers, especially in pulmonary complaints. The dryness of the atmosphere makes the heat during the summer endurable and in the winter the cold inappreciable. Through the heated season the nights are delightfully cool and a good night's rest is usually assured. At Laramie and Centennial the normal annual temperature is about 40° F., being a trifle higher at Laramie.

The following table shows the normal monthly and annual temperature and precipitation for Laramie and Centennial:

Normal monthly and annual temperature and precipitation.

Month.	Centennial.		Laramie.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	22.5	0.33	21.3	0.23
February	19.4	3.17	20.6	.35
March	25.8	2.12	27.4	.91
April	34.5	3.25	37.4	1.19
May	46.8	1.28	47.5	1.41
June	55.5	.84	56.4	1.12
July	60.5	1.00	62.5	1.30
August	58.1	1.32	61.7	1.09
September	50.6	.69	53.4	.73
October	41.0	1.50	41.9	.86
November	32.7	.38	31.6	.25
December	22.7	1.09	21.8	.37
Year	39.1	16.85	40.3	9.81

The coldest weather usually occurs in December, January, February, and March, the average temperature for these months being about 25°. July and August are usually the warmest months in the year.

The period of greatest precipitation at Laramie is during the months of April, May, June, and July, the normal for each month being 1.20 inches. At Centennial the annual rainfall is 16.85 inches, or almost double that at Laramie, where the records show 9.81 inches. This great difference is due to the tendency of the storms to follow the mountains. The figures showing the climatic conditions at Laramie are more representative of the whole area than those for Centennial, since the proximity of the mountains at the latter place makes the conditions there more local than general.

Agriculture is almost wholly dependent on irrigation, the rainfall being insufficient to mature the crops.

The dates of the last killing frosts in spring vary from May 24 to June 6 and of the first in fall from August 16 to September 1. Frost is known to have occurred every month in the year.

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed, with the exception of a part of the eastern portion, lies in the Laramie Plains. These plains extend in a broad valleylike area with a dimension of 35 miles east and west and of 80 miles north and south. Since the formation of these plains the river has cut down through them, forming the Laramie Valley proper. In the western part of the area this valley assumes its maximum width of about 4 miles. Following the course of the river it gradually becomes narrower, until 5 miles north of Laramie it is only 1 mile wide.

The Laramie River falls between 200 and 300 feet in traversing the area. It flows usually between low banks, the land on each side sloping gradually back to the hills or level uplands, but at a few points and for short distances there are precipitous bluffs.

The uplands are more or less rolling, gradually rising toward the mountains on the west and the Laramie Hills on the east. On the west the uplands reach an elevation of 7,370 feet, and on the east the hills rise to an elevation of 7,500 feet above sea level.

The uplands are dotted with many lakes, most of which are fed by seepage water and the remainder by springs. Large basins also occur in this part of the area. In parts of Ts. 16 and 17 N., R. 74 W., and in Ts. 15 and 16 N., R. 74 W., two large basins are found. The former has an area of approximately 10 square miles and the latter of about 3 square miles. In secs. 27 and 28, T. 15 N., R. 75 W., along the border of the area, another basin is found with an area of about 2 square miles. Small lakes found in these basins usually contain a high percentage of alkali.

Most of that part of the area surveyed lying within what is known as the Laramie Plains is correlated with the Cretaceous period. The rocks exposed along their edge are of earlier ages and are important in the formation of the soils. The Laramie Hills, which mark the eastern boundary of the area, belong to the Archean time, and are composed chiefly of granitic rocks. Overlying the western slope of the Laramie Hills is a series of Upper Carboniferous sands and limestones, dipping to the west at angles varying from 6° to 12°.

The Triassic series, which overlies the Upper Carboniferous, contains many beds of dark-red sandstone. Some of these beds are exposed and are prominent in soil formation along the eastern border of the area. Red shales and thick beds of gypsum occur near the base of this sandstone.

Overlying the Triassic rocks are rocks of the Jurassic period, and these are in turn overlain by the Rocky Mountain Cretaceous, which cover the valley.

The Medicine Bow Range, which forms the south and west boundaries of the Laramie Plains, belongs to Archean time. The rocks found

here consist chiefly of quartzites, granites, gneisses, and schists. These rocks are important in the formation of the soil types of the upland north and west of the Laramie River.

Glaciers also have played an important part in the formation of the soils of the Laramie Plains. Early in Quaternary times glaciers existed at the heads of the Laramie and Little Laramie rivers. At this time the area was an inland lake, and as icebergs broke off from the glaciers they floated to some protruding hill and there melted away, depositing the material carried down by them.

Rocks of the Azoic, Paleozoic, and Mesozoic eras were ground up and transported to the plains by the glaciers and there deposited, later becoming a part of the soils.

There was also a period of calcareous deposits, and the bowlders carried down by the glaciers were enveloped in a thin layer of calcareous material. This is still found, especially where bowlders have been recently unearthed.

The gravel found in these colluvial soils of the uplands consists chiefly of fragments of sandstone and limestone, quartz, gneiss, schist, and granite, while underlying the colluvial material at various depths, and outcropping here and there, are extensive beds of yellow and blue shales of the Cretaceous period. The yellow shales occur, as a rule, on the north and west of the Laramie River. They trend in a northeasterly and southwesterly direction and probably underlie the greater portion of the area northwest of the river. Occasionally outcrops of blue shales occur in the yellow shales, but these are local. On the south side of the river, extending from the foothills of Jelm Mountain east and north probably to the Red Beds east of Laramie, the underlying materials are blue shales. These shales contain indications of oil, and a well is being drilled in an exposure in sec. 13, T. 14 N., R. 75 W. At the time this well was visited the drill had reached a depth of 600 feet. The shales extended to this depth, with alternating layers of sand.

Gypsum crystals are found in abundance where the yellow shales outcrop. The blue shales probably contain the larger amount of alkali. The soil formed from these shales is heavy, almost a clay loam.

SOILS.

The soils of the Laramie area may be divided into three general classes, according to their origin or manner of formation. These are, first, residual soils, or soils formed from the degeneration of rocks in situ; second, alluvial soils, or those formed from material deposited by the river; third, colluvial soils, or those formed from material carried down from the mountains by transporting agencies.

Each of the soil types occurring under these general classes is quite distinct in its typical form, and the boundaries are often marked by topographical as well as textural differences.

The following table shows the areas of the several soil types mapped:

Areas of different soils.

Soil.	Acres.	Per cent.
Laramie sandy loam	86,272	43.6
Redfield sandy loam	42,624	21.6
Laurel sandy loam	29,440	14.9
Laramie gravelly loam	19,200	9.7
Billings clay	16,064	8.0
Gypsum	2,304	1.2
Riverwash	1,792	.9
Total	197,696	

RIVERWASH.

The Riverwash, which occupies only a small proportion of the area, is a coarse, nonagricultural soil, consisting of small waterworn gravel and coarse sand. It occurs as a narrow strip—averaging about three-eighths of a mile in width—along the river from a point about 6 miles southwest of Laramie to about the same distance north of that town. It is the result of river action and exists as low, level land cut by old river channels. During the summer it is usually dry, but during the wet season it is for the most part covered with water. A scattering and scanty growth of willow is about the only vegetation on this soil type. On account of the small proportion of fine material in this soil it is usually classed as unproductive and has no agricultural value.

LAUREL SANDY LOAM.

The soil of the Laurel sandy loam is an alluvial deposit, varying in depth from 2 to 6 feet. The soil, which is usually black, although sometimes dark yellow or gray, ranges in texture from a coarse sandy loam to almost a loam. The loam phase occurs in the low-lying places, where there has been an accumulation of finer material washed in from higher surrounding areas. The subsoil consists of a yellow or gray sand grading into coarse sand and gravel at lower depths. Patches of sand and gravel occur over this type in the form of small hummocks or ridges. Near these sand and gravel ridges, and where the type borders the river, gravel is found in small amounts on the surface. The following table of mechanical analyses of the fine earth of this soil will convey an idea of its texture.

Mechanical analyses of Laurel sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9346	¼ mile W. of NE. cor. sec. 15, T. 14 N., R. 75 W.	Sandy loam, 0 to 36 inches.	1.40	2.80	12.60	14.10	29.80	19.16	13.10	8.40
9344	¼ mile W. of E. cen. sec. 29, T. 16 N., R. 73 W.	Dark sandy loam, 0 to 24 inches.	1.15	.62	3.10	3.00	17.94	25.58	31.50	18.16
9347	Subsoil of 9346....	Coarse sand and gravel, 36 to 72 inches.	.34	11.16	25.54	20.96	20.42	7.96	2.70	2.22
9345	Subsoil of 9344....	Sand, 24 to 72 inches.	.09	5.64	23.82	19.10	27.20	13.50	4.70	6.20

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 9344, 7.20 per cent; No. 9345, 1 per cent.

The main body of this type of soil occupies the valley floor proper, extending along the river throughout the entire area. Small, fingerlike patches extend back toward the uplands for some distance, following the course of the small streams which empty into the Laramie River. Along the river the area varies in width from one-eighth of a mile to about 2 miles. Along the streams the average width is much less, rarely exceeding half a mile. Almost all of this soil occurs on the southeast side of the river.

The physiographic features of the area occupied by this soil are not very marked. The surface is comparatively level, with a slight slope toward the river. The small hummocks and ridges of sand and gravel already mentioned occur here and there, but rarely exceed an elevation of 3 feet. The surface is cut by sloughs, old river channels, and small swampy areas.

The natural drainage, except in the higher places, is comparatively poor. During the wet season the type is subject to overflow from the Laramie River, while owing to its low-lying position the water table is near the surface most of the year. At the time this soil was surveyed the water table was rarely found at a depth of more than 6 feet.

A system of artificial drains that would be effective during the dry season both in keeping the water table sufficiently below the surface to allow the growth of shallow-rooted crops and in removing the alkali would be of great benefit to this soil type. These drains would not only free the soil of alkali already present, but would check the further accumulation of alkali within the root zone of plants. To be most effective these drains should be laid as deep as the level of the river would permit.

The Laurel sandy loam is of alluvial origin, having been deposited in comparatively recent times by the Laramie River. The heavier phase of this soil was probably laid down in places where the river was at one time sluggish, and has been modified by the washing of the finer material into depressions. This type contains considerable organic matter, which gives it its characteristic black or grayish color.

Owing to the low position which this soil occupies, and as a result of seepage from the uplands, alkali occurs in considerable quantities over the area. It varies in amount from 0 to 3 per cent, with the greatest amount near the bluffs. In going toward the river from the bluff lines the alkali gradually decreases in amount and finally disappears, leaving a narrow strip along the river practically free from injurious salts. Only in a few small areas does the alkali extend to the river.

The depth to which alkali occurs in this type depends upon the depth of the soil. Where the soil is only 2 feet deep alkali is found only in the first 2 feet, the underlying sand and gravel being practically free from it. Where the soil extends to a depth of 6 feet alkali is also found extending to this depth. It is in places where the soil is deep that the greatest quantity of alkali is found. The highest percentage of alkali usually occurs in the second or third foot, this also seeming to vary with the depth of the soil.

Hay is the principal crop produced on this soil. It is made from the native grasses, chief among which are wire grass, salt grass, grama grass, blue stem, and in some places red fescue. All these have a high nutritive value. Rye grass, reed grass, and cord grass also grow on this soil, but are considered of little value on account of their hard and woody fiber when matured. The average yield of hay is about 1 ton per acre. On soil that is practically free from alkali 2 tons per acre have been harvested, while on the poorer alkali soil the yield rarely exceeds one-fourth of a ton.

Barley, wheat, potatoes, and some other vegetables are grown upon this soil. They give fairly good yields, but up to the present time little attention has been paid to their cultivation. Pease and beans do well, but are raised only in small garden plots for home use.

This soil is well adapted to the growing of such truck crops as can withstand the climate. For this purpose only the hardier and early maturing varieties should be planted. Barley, wheat, and oats would do well on this soil, and on the higher portions alfalfa can be grown with a fair degree of success. The production of alfalfa on this soil is not, however, to be recommended unless a thorough system of drainage is first established. Under present conditions the water table is too near the surface and the soil too wet and heavy for alfalfa to do well. The soil is preeminently adapted to the production of hay. and as already stated is largely used for that purpose.

REDFIELD SANDY LOAM.

The Redfield sandy loam, which is known locally as the "red lands" or the "red beds," in its typical formation consists of a red sandy loam with a depth of 6 feet or more. It is subject, however, to considerable variation in texture, due to the washing out of the finer and more soluble material and to the commingling of this type with soil formed from adjoining areas of limestone. Sometimes it is a coarse sandy loam and again it approximates a typical loam, the difference depending largely upon the position occupied. In the higher areas of this soil the coarse sandy loam phase occurs, usually mixed with limestone fragments varying from a fraction of an inch to several feet in diameter. The coarse material rarely exceeds a depth of 6 feet and is underlain by the finer material.

The soil is not deep on the higher places, and in many instances the underlying sandstone rock is exposed. This rock usually consists of a medium coarse-grained sandstone of varying thickness, underlain by a red shaly sandstone which on exposure disintegrates very rapidly, forming the fine sandy loam phase.

The heaviest phase of this soil occupies depressions and is a result of wash from the uplands. It consists of a heavy red or brownish loam, generally free from limestone fragments, extending to a depth of more than 6 feet. This phase occurs locally and is not of sufficient extent to classify as a separate soil type.

In parts of this soil type where limestone occurs it is in some places found on top of the red soil and in other places beneath it. In some places limestone and red sandstone outcrop side by side. The materials derived from these rocks pass into each other by almost imperceptible gradations. In some places they seem to be mingled in about equal proportions. These conditions made it impossible to draw accurate boundary lines between the materials derived from the one or the other rock, and for this reason it was necessary to map them as one soil type, although in their typical forms the resulting soils are very different.

The following table shows the texture of the fine earth of samples of this soil:

Mechanical analyses of Redfield sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9348	E. cen. sec. 9, T. 14 N., R. 73 W.	Sandy loam, 0 to 24 inches.	2.94	2.38	8.50	5.30	16.70	29.20	23.24	14.60
9349	Subsoil of 9348......	Fine sandy loam, 24 to 72 inches.	1.06	.20	.90	.70	2.74	54.54	33.10	7.80

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 9348, 17.20 per cent; No. 9349, 13.40 per cent.

The Redfield sandy loam occupies the eastern part of the area, extending along the boundary for a distance of about 20 miles, and having an average width of about 4 miles. It embraces the greater portion of the uplands east of the river, and in no instance does it occur west of the river.

The surface of this soil consists of level and rolling uplands and hills. The soil has been washed considerably and small valleys and gullies have been formed. The surface, as a rule, is very broken and there is considerable fall toward the river. East and southeast of Laramie the surface is very hilly and rolling, while some distance northeast of that town it becomes more level. The highest elevation reached by this soil is about 7,475 feet.

Owing to its elevated position this soil has excellent natural surface drainage. The soil is also of a loose, porous nature, and water passes through it very readily. The drainage is thus excessive. On account of the rolling and hilly surface this soil can not be irrigated.

This type is a residual soil derived from the rocks over which it lies. The coarse sandy phase represents the residue of the disintegrated material, the finer particles having been washed away by rain water. The fine sandy loam phase is the result of the decomposition of the red shaly sandstone which usually underlies the coarse sandy phase. Most of the loamy areas of this soil are also derived from this same rock formation, while the heaviest areas have been formed from the accumulation of the finer and more loamy material in the depressions and low-lying areas. The decomposition of the limestone present in this soil, and adjacent to it, has also played an important part in its formation.

Except in the low-lying areas this soil does not contain a sufficient quantity of alkali in the first 6 feet to injure even the most sensitive crops. The hills are, nevertheless, highly contaminated with the alkali salts. In good exposures alkali may be seen seeping out of this soil. The writer has observed stock eating this soil, undoubtedly for the salts which it contains. About 2 miles north of Laramie, where this type extends to the river, in a 3-foot test a little over 0.40 per cent of alkali was found. The test was made in a comparatively high place and the land had a good slope toward the river. About one-fourth mile east of this the alkali may be seen seeping out of the exposed rocks, which deposit probably accounts for the alkali occurring at this particular place. The hills also contain considerable quantities of gypsum—judging from the beds of secondary gypsum that occur at their base—evidently deposited in the basinlike depressions from seepage waters.

Presumably, on account of its leachiness, this soil is not naturally very productive. In the lower places, however, and where it is mixed

with limestone in considerable quantities, it would prove much better. However, it can not be irrigated, and for this reason no crops are grown upon it. This soil is used for range purposes, the principal grass being the sweet or salt sage.

LARAMIE SANDY LOAM.

In its typical form the Laramie sandy loam consists of a coarse sandy loam varying in depth from 2 to 6 feet and underlain by sand and gravel. The soil gradually becomes heavier with depth, and in some localities grades into a gritty loam which generally extends to the subsoil.

In the southeastern part of T. 16 N., R. 74 W., the soil consists of a light-gray sandy loam, with a depth of 2 feet, underlain by a yellowish sand. This sand, however, varies in color from a light yellow to gray and in some cases grades into a reddish color. Small gravel is found in the upper part of the soil, but becomes proportionally less and finally disappears in the deeper soil, though occurring again in the subsoil.

In the lower lying areas of this type the soil is a heavy, gritty loam. When this phase is subjected to heavy applications of water, it has a tendency to puddle and on drying becomes very hard and lumpy. The soil in these localities rarely exceeds a depth of 6 feet and is underlain by sand and gravel.

Along the Pioneer Canal the soil is quite heavy and contains considerable organic matter. It is here under water most of the season, a condition which favors the growth of rank vegetation and the accumulation of humus. A similar condition also exists under the canals in the western part of the area. The soil in the lake bottoms is also very heavy, consisting of a gritty silt or clay loam, mixed with organic matter.

Gravel occurs in varying amounts over most of this soil type, being more plentiful in the western part. Farther from the mountains it decreases both in size and quantity, finally disappearing or occurring only in local spots. Originally all the gravel was covered with a coating of calcareous material, as is most of it at present. This feature is most noticeable where gravel has recently been brought to the surface, for on long exposure the coating is dissolved. The gravel in this soil consists of quartz, sandstone, and limestone. Northwest of Laramie are found outcrops of a medium fine-grained sandstone of a brownish or reddish color and containing a considerable quantity of iron.

Following is a table showing the mechanical analyses of the fine earth of this soil's type:

Mechanical analyses of Laramie sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9352	$\frac{1}{8}$ mile W. of $\frac{1}{4}$ N. of SE. cor. sec. 31, T. 16 N., R. 73 W.	Coarse sandy loam, 0 to 18 inches.	0.82	4.70	9.06	7.70	25.06	25.88	12.00	15.70
9350	$\frac{1}{4}$ mile W. of $\frac{1}{4}$ S. of NE. cor. sec. 4, T. 14 N., R. 75 W.	Coarse sandy loam, 0 to 48 inches.	.03	6.74	16.20	9.22	15.08	6.40	11.32	35.04
9354	Subsoil of 9352....	Sand and gravel, 48 to 72 inches.	.15	5.80	17.14	16.14	33.86	12.56	4.70	9.60
9353	Subsoil of 9352....	Gray loam, 18 to 48 inches.	.60	4.40	9.72	7.12	23.72	20.74	10.00	24.26
9351	Subsoil of 9350....	Dark loam, 48 to 72 inches.	.44	2.52	6.64	4.32	5.42	3.00	32.46	45.70

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No 9351, 5 per cent; No. 9350, 15.40 per cent; No. 9353, 7 per cent; No. 9354, 2.20 per cent.

The Laramie sandy loam, which is the most extensive type in the survey, covers most of the upland portion of the Laramie Valley. One unbroken body of it, with an average width of about 6 miles, traverses the entire area in a southwesterly and northeasterly direction. Only small patches occur on the south and east side of the Laramie River.

The Laramie sandy loam consists of rolling uplands and level plains. It rises gradually from the river until the western portion of the area is reached. The fall is then to the northwest, toward the Little Laramie River. The highest elevation reached within the area is about 7,375 feet. The surface is dotted by many lakes and basins. These lakes lie, as a rule, in the immediate course of the canals, and usually contain a heavier type of soil. The basins are quite large, varying in size from 2 to 15 square miles, and these also contain a heavier type of soil.

The soil is generally of sufficiently coarse texture to permit the rapid percolation of the water, and the underlying stratum of sand and gravel is well adapted to carrying away the surface waters, and except in the basins the drainage is good. At the same time the soil retains water well. The small lake basins or low places in the uplands can not be drained, owing to lack of outlets for the drainage water. The level upland areas of this soil type can be irrigated.

The Laramie sandy loam is of colluvial origin, i. e., has been brought from the hills and mountains on the south and west and deposited on the uplands through the agencies of water, wind, and ice. The mountains on the south and west have been lowered many hundreds of feet and most of this material has found its way to the valley below. Glaciers have played an important part in the formation of this soil.

Except in the low-lying areas this soil contains less than 0.20 per cent of alkali in the first 6 feet. The deep soils and rock formations of the uplands are, however, highly impregnated with alkali. A boring was made on the level upland three-eighths mile south of the northwest corner of sec. 16, T. 15 N., R. 74 W., and while there was no alkali in the first 2 feet the third foot contained from 0.20 to 0.40 per cent. Gravel prevented a deeper boring being made. Along cuts in this soil alkali can be seen seeping out, and the lakes occurring in it are generally highly alkaline, while in the lower areas along the river from 0.60 to 1 per cent of alkali occurs. In seepage areas under the Pioneer Canal alkali also is found in this soil in considerable quantities, varying from a slight surface accumulation to from 0.60 to 1 per cent. Gypsum crystals are also found in this soil, but only in small quantities.

This type is the most extensively farmed of any of the soils in the area. The principal crops grown are wheat, oats, barley, alfalfa, and potatoes. Wheat yields on an average from 20 to 35 bushels per acre, the yield of oats varies from 30 to 50 bushels per acre, depending upon the water supply, while potatoes yield from 100 to 175 bushels. Barley also gives good yields. The grass grown on this soil yields from three-fourths to 1 ton of hay per acre. Alfalfa yields 4 tons from the two cuttings usually obtained in a season.

Most of this soil at present is devoted to grazing purposes. Among the principal native pasture grasses are blue stem, grama grass, buffalo grass, and June grass.

This soil is rich in plant food, and where the water supply is sufficient to mature the crops it is adapted to all crops suited to the climate. It is especially valuable for the production of wheat, oats, and barley, only the spring varieties of which can be successfully grown. The winter season is usually too severe for fall-sown grain. Barley gives fairly good yields and is of good quality. Alfalfa is also well adapted to this soil. In its virgin state this soil is well adapted to potatoes and other vegetables of the hardier and earlier maturing kinds. It would also prove well suited to fruit, but on account of the severe climate fruit growing can not be recommended.

LARAMIE GRAVELLY LOAM.

The soil of the Laramie gravelly loam consists of a coarse sandy loam mixed with large amounts of gravel and varying in depth from 2 to 3

feet. The color ranges from yellow to dark gray, the latter color predominating. The subsoil consists of sand and gravel and extends to a depth of more than 6 feet. On the surface the gravel making up so large a part of this soil varies in size from small pebbles to bowlders about 12 inches in diameter. In the deeper layers the gravel is much larger and increases in size with depth.

At depths varying from 6 to 10 feet or more this soil type is underlain by yellow shales, which may be seen outcropping at the foot of the bluffs and in the lake bottoms.

This type does not cover extensive areas in the present survey. The most typical bodies are found in the western part, covering little more than half of T. 14 N., R. 76 W. Another small area occurs in the west central part of T. 16 N., R. 74 W.

The surface of this soil is comparatively level, although in the southwestern part of T. 14 N., R. 76 W., and in the northeastern part of the same township it is somewhat broken and hilly and some sharp bluffs are found along the southern boundary. The highest elevation attained is about 7,430 feet.

On account of the loose, porous character of this soil the natural surface drainage is excessive. Like the Redfield sandy loam it has very little power to retain water. In the lower places where the yellow shales are near the surface small lakes are found. Otherwise the soil is dry throughout the season.

In origin this soil is both alluvial and colluvial. Much of the material forming it has been brought down from the mountains in the same way as the materials forming the Laramie sandy loam, but the sand and gravel making up the subsoil have been deposited at some past time by the Laramie River.

This soil is practically free from alkali. In the lower places where the land is subject to seepage from the canals slight surface accumulations occur, but nowhere are there found injurious quantities of these salts.

Owing to the large percentage of gravel in this soil it is not a desirable type for farming. It is used almost entirely for grazing purposes, although in the lower areas under the Pioneer Canal some hay is produced. The yield is about the same as on the other low-lying soils of the valley.

No mechanical analyses of this soil were made, owing to the great proportion of large stones it contains and its relatively small value for agriculture.

BILLINGS CLAY.

The Billings clay is the heaviest type of soil found in the area and occurs in two different phases, one derived from a yellow shale and the other from a black or blue shale. The soil of the former is a

heavy yellowish loam or clay usually 6 feet or more in depth. It has a greasy feel and contains considerable gypsum in the crystal form. The soil derived from black or blue shale is a very heavy, sticky loam, usually exceeding a depth of 6 feet. It is very compact and practically impervious to water. In both of these phases are found fragments of shales, and near the base of the hills some gravel is also present.

The following table gives the mechanical analysis of a sample of this type:

Mechanical analysis of Billings clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9355	SE. cor. sec. 32, T. 16 N., R. 74 W.	Heavy loam, 0 to 72 inches.	1.24	0.00	0.56	0.76	4.96	8.68	28.20	57.00

The above sample, No. 9355, contained 16.60 per cent of calcium carbonate ($CaCO_3$).

The Billings clay occurs locally, either encircling the base of the hills or lying at the foot of bluff lines. The phase derived from yellow shale occurs chiefly northwest of the Laramie River, while that owing its origin to the disintegration of the black and the blue shale is found mainly on the opposite side, although each occurs to some extent on both sides of the river. The lake bottoms and the lower part of the basins are also composed of this type of soil.

The surface configuration of the Billings clay varies considerably, depending upon its location. At the foot of the hills it has a gentle slope toward the river. On the uplands it usually occurs as local depressions, in most cases forming lake bottoms. It sometimes occurs as bluff lines around basins. In T. 16 N., R. 74 W., the bluff lines marking the boundaries of the basin are composed of this type. Here it extends back from the bluffs for some distance before it is covered by the materials forming the Laramie sandy loam.

The drainage of this soil is very poor. The surface is usually so hard and compact as to be practically impervious to water. It would be possible, however, to drain the areas of this soil lying along bluff lines, but the operation would be tedious and expensive, as drains would have to be placed very close together to be effective. Where this type occurs in the basins drainage is impracticable, as there are no outlets.

The Billings clay is a residual soil formed by the decomposition of different colored shale rock. This soil has been washed down from the higher lying lands, forming small fan-shaped areas extending from the bluff lines.

This soil type contains a very high percentage of alkali, derived from the shales, which are highly impregnated with these injurious salts. Most of the alkali found in the lower parts of the valley is the result of seepage from these shale formations. The percentage of alkali found in this soil varies from 0.20 to over 3 per cent, the largest quantities being found where the water table is within from 6 to 10 feet of the surface. The lakes occurring in these areas are also highly alkaline and in some instances contain a low percentage of carbonates.

No crops are grown on this type, and foxtail grass, greasewood, and salt bushes form the principal vegetation. Alkali is present in too large quantities for crops to do well. At present but little of this land is under irrigation.

GYPSUM.

Quite extensive deposits of gypsum occur along the foothills of the Redfield sandy loam. Three beds were found in the area, one in the north central part of T. 15 N., R. 73 W., just south of Laramie; another in the north central part of T. 16 N., R. 73 W., and the third near the center of T. 17 N., R. 73 W., extending as a narrow strip from section 16 through sections 17 and 20 and into a part of section 19.

The gypsum is covered by a brown or reddish loam varying in depth from a few inches to over 6 feet, the soil being deeper near the hills.

The gypsum occurs in the secondary form, and its source is undoubtedly in the Redfield sandy loam. At one time there was probably a ridge between the river and the hills, and as the gypsum leached out of the hills it was deposited in this basin.

Alkali is found in large quantities in this deposit. It varies from 0.20 to 3 per cent, the heaviest amount occurring near the center of the deposit. The soil is usually covered with a heavy growth of greasewood and salt bushes.

WATER SUPPLY FOR IRRIGATION.

The water for irrigation in this area is drawn from the Laramie River. During the early part of the season the supply is more than adequate for the area of land under irrigation, but later in the season the supply runs short. The shortage usually begins in the latter part of August and lasts until late in the fall.

Two analyses of the water used for irrigation in the area were made in the Bureau laboratory. One was taken from the Pioneer Canal

west of Laramie, and the other from the Laramie River, northwest of the town. The results are given in the following table:

Analyses of irrigation water, Laramie area.

[Parts per 100,000.]

Constituents.	Pioneer Canal, west center sec. 31, T. 16 N., R. 73 W.	Laramie River, center sec. 29, T. 16 N., R. 73 W.
Ions:		
Calcium (Ca)	2.2	5.5
Magnesium (Mg)	1.1	2.8
Sodium (Na)	1.4	2.9
Potassium (K)	1.0	3.4
Sulphuric acid (SO_4)	6.0	21.0
Chlorine (Cl)	....	1.7
Bicarbonic acid (HCO_3)	9.8	14.5
Conventional combinations:		
Calcium sulphate ($CaSO_4$)	7.4	18.7
Magnesium sulphate ($MgSO_4$)	1.0	9.8
Magnesium bicarbonate ($Mg(HCO_3)_2$)	5.4	5.4
Potassium bicarbonate ($KHCO_3$)	2.6	3.8
Potassium chloride (KCl)	....	3.6
Sodium bicarbonate ($NaHCO_3$)	5.1	10.5
Total solids	21.5	51.8

The above table shows that the water used for irrigation is of an excellent quality. As would be expected, the water in the Laramie River, where the above sample was taken, contains more than twice the amount of soluble salts in the samples taken from the Pioneer Canal. The Pioneer Canal is taken out of the river in the western part of the valley and follows along on the uplands. It is therefore not affected by seepage waters. On the other hand, the river water is more or less contaminated by seepage from the canals, which accounts for its increased salt content. At the time the above samples were taken the river was low and the salt content shown in the table is somewhat higher than it would be earlier in the season. A field determination made about two months earlier, the water being taken from the lower end of the Pioneer Canal, shows the salt content to be 16 parts total solids per 100,000 parts solution. From these determinations it will be seen that no appreciable amount of salt will be added to the soil by the application of these waters.

Several canals have been built in the area, but most of them are small and are owned by private individuals. The Pioneer Canal, which is the largest and most important canal in the area, was built by a stock company in 1879. It traverses the area in a northwesterly direction for a distance of about 35 miles. In the northwest corner of sec. 28, T. 14 N., R. 76 W., it runs into a small lake which is used as a reser-

voir. The capacity of this canal is about 306 second-feet. The total irrigable area under this canal is estimated at about 50,000 acres.

The Fisher Canal, a private canal built in 1887, traverses the area in a northeasterly direction for a distance of 7 miles. The average fall of this canal is 5.28 feet in 100 feet. The capacity is 89.96 second-feet, and the area possible of irrigation approximately 3,000 acres.

The Riverside No. 1 Canal was built in 1884. It is owned by the Riverside Livestock Company, and traverses the area for a distance of about 5 miles. It has a fall of 5.3 feet per mile and a capacity of 13.68 second-feet. About 2,000 acres of land are irrigated by this canal.

The Walcott ditch was constructed in 1873, and is one of the first canals built in the area.

No definite data were obtainable regarding the Last Chance ditch or the Parker ditch. They are both taken out of the river a short distance northwest of the center of sec. 31, T. 14 N., R. 76 W., and traverse the area in a northeasterly direction. The Parker ditch is about 6 miles long and the Last Chance ditch has a length of about 15 miles. The capacity of these ditches is about the same as that of the Fisher Canal. They are owned privately and are used to irrigate the uplands in the western part of the area.

The Haley Canal is taken out of the river in the southeastern corner of sec. 19, T. 17 N., R. 73 W. It parallels the river for a distance of about 10 miles. It is used to irrigate the lowlands between it and the river in the northern portion of T. 17 N., R. 74 W. Its capacity is about the same as that of the Pioneer Canal.

The Haley ditch and the Hecht ditch are taken out of Brown Creek outside of the area surveyed. The lower end of the Haley ditch passes through the area for a distance of about 6 miles. The Hecht ditch traverses the area for a distance of about 3 miles. The latter is used in irrigating lands in the large basin about 6 miles northwest of Laramie.

Many other private ditches occur in the area, but they are not of sufficient importance to warrant separate discussion.

UNDERGROUND AND SEEPAGE WATERS.

The character and position of underground and seepage waters is important, both in their relation to crops and the distribution of alkali in soils. In nearly all regions where irrigation is necessary for successful farming, and where considerable quantities of alkali exist in the soil or irrigation water, there is great danger in overirrigation and the consequent rise of alkali to the surface. A considerable part of the once productive lands of the Laramie area have been injured in this manner, especially the lands under the Pioneer ditch and in the lower areas near the river, subject to seepage from the uplands.

The water map accompanying this report shows the position of the underground and seepage waters at the time the survey was made. The grade of land mapped as 0 to 3 feet represents swamps, sloughs, and overflowed lands. These consist of open bodies of water and waste lands. Such areas as these, as well as areas where the water lies between 3 and 6 feet from the surface, require artificial drainage. Drainage in most cases would not be difficult, as the fall toward the river is generally sufficient. In the lower and more level places, however, drainage by gravity would be impracticable.

No immediate danger need be expected from the rise of alkali salts where the water is from 6 to 10 feet below the surface, but where this condition exists great care should be exercised in irrigation. If an excess of water be used continually it will sooner or later result in the rapid rise of the water to or dangerously near the surface, and a consequent concentration of alkali salts within the root zone of plants.

The following tables show the character of the alkali found in the seepage water and also in the water of the Soda lakes:

Analyses of well water and Soda Lake water.

[In parts per 100,000.]

Constituents.	Well, north center sec. 24, T. 14 N., R. 75 W.	Soda Lake, north center, sec. 4, T. 14 N., R. 75 W.
Ions:		
Calcium (Ca)	46.1	6.4
Magnesium (Mg)	12.9	33.7
Sodium (Na)	9.4	200.4
Potassium (K)	9.4	15.2
Sulphuric acid (SO_4)	159.6	504.2
Chlorine (Cl)	....	40.8
Bicarbonic acid (HCO_3)	37.5	15.1
Carbonic acid (CO_3)	2.3	8.4
Conventional combinations:		
Calcium sulphate ($CaSO_4$)	156.8	21.7
Magnesium sulphate ($MgSO_4$)	61.3	166.9
Magnesium bicarbonate ($Mg(HCO_3)_2$)	3.0	....
Potassium bicarbonate ($KHCO_3$)	24.0	....
Sodium bicarbonate ($NaHCO_3$)	28.1	20.8
Sodium carbonate (Na_2CO_3)	4.0	14.8
Potassium chloride (KCl)	....	29.9
Sodium chloride (NaCl)	....	44.7
Sodium sulphate (Na_2SO_4)	....	526.4
Total solids	277.2	825.2

Chemical analyses of samples of lake water.

[Field determinations.]

No. of sample.	Location.	Total salt content.	Carbonate.	Bicarbonate.	Chlorine.	Sulphates.
27	Seepage water, NW. center sec. 20, T. 16 N., R. 73 W.	130	Tr.	96.7	13.9	Not tested.
37	Lake water, W. ⅛ of NE. corner sec. 16, T. 16 N., R. 73 W.	834	21.06	33.36	174.18	Heavy.
43	Lake water, NE. corner sec. 12, T. 16 N., R. 74 W.	190	9.47	20.85	11.61	Do.
54	Lake seepage, SE. corner sec. 16, T. 15 N., R. 74 W.	284	Tr.	23.35	16.25	Do.
55	Alkali lake, N. central sec. 22, T. 16 N., R. 74 W.	670	10.58	25.03	75.47	Do.
85	Lake water, central sec. 5, T. 14 N., R. 75 W.	165	29.48	66.75	Slight.	Medium.

The analyses of lake waters in the foregoing table were made in the field. The analyses of the well and the soda lake waters given in the first table were made in the Bureau laboratory.

The above tables show the principal salts found in the subsoil and drainage waters to be sulphates and bicarbonates, with varying amounts of chlorides. Carbonates occur, but generally in very slight quantities. Sulphates occur in larger amounts than any other of the salts.

The soda lakes are not the result of seepage from the surrounding lands and their chemical composition is somewhat different from that of the lakes formed from seepage. The former contain 715 parts sulphates per 100,000 parts of solution. These occur in the form of calcium sulphate, magnesium sulphate, and sodium sulphate. The last form occurs in largest quantity—526.4 parts per 100,000 parts of solution. Several years ago the material collected from these lakes was used in the manufacture of carbonate and caustic soda by a plant located at Laramie. Later, however, the works were compelled to shut down, being unable to compete with eastern manufacturers.

ALKALI IN SOILS.

Most of the alkali found in the Laramie area occurs in the lowlands along the Laramie River, although quite extensive alkali areas also occur along the Pioneer Canal and in some of the large basins.

On the southeast side of the river alkali occurs in varying amounts throughout areas extending from the southeast corner of T. 14 N., R. 76 W., to about 2 miles north of Laramie. The heaviest accumulations occur in the Billings clay in the south central part of T. 14 N., R. 75 W., and T. 15 N., R. 74 W. The gypsum deposits also contain considerable alkali. These areas occur in the north central parts of T. 15 N., R. 73 W., and T. 16 N., R. 73 W., and in secs. 16, 17, 20, and 19, T. 17 N., R. 73 W.

On the northwest side of the Laramie River most of the alkali found is under the Pioneer Canal. Near the central part of T. 15 N., R. 74 W., and about 4 miles to the southwest, is found the heaviest accumulation of alkali under this canal, and another large area occurs in the western part of T. 16 N., R. 73 W. In the western portion of the area slight surface accumulations are found. They lie under the canals and are the result of seepage from the canals. In the large basins in the northwestern part of T. 16 N., R. 74 W., alkali is found in considerable quantities. Small patches occur around lakes and in local depressions on the uplands.

The original source of the alkali found in the Laramie area is in the exposed banks of clay, shale, and sandstone found in and around the area. Surface accumulations may be seen where these clays, shales, and sandstones outcrop. The alkali contained in these deposits is continually leaching out and being stored in the soil, already containing too large a percentage of soluble salts for plant growth. Where such land is irrigated or washed by meteoric waters the alkali is dissolved and carried in the drainage water to the lower lying soils of the valley, in turn rendering them unfit for cultivation. Most of the alkali areas in the soils of the lower parts of the area have been formed in this way.

The alkali found in the basins or lake bottoms has come from the hills surrounding them. It has been washed into them by seepage waters, until the amount they contain is very large.

Springs are also the source of alkali in the area. This is especially the case of the soda lakes in the north central part of T. 14 N., R. 75 W. The spring waters that feed these lakes undoubtedly run through extensive deposits of the different salts, parts of which are brought to the surface in solution. While it is true that these spring waters bring considerable alkali to the surface, the amount is slight compared with the alkali that originates from the soils and certain of the rock formations. There is a great store of alkali in these clays, shales, and sandstones, and in time alkali will have accumulated in such quantities as to make agriculture impossible, unless great care be exercised in irrigation and more attention be given to artificial drainage, so that the salts may be removed as fast as they accumulate.

The character of the alkali found in the soils is much the same over the entire area. From a number of chemical analyses of the soils made in the field, bicarbonates and sulphates are seen to be the principal salts found in the area. Only very slight traces of carbonates (black alkali) are found. Chlorides occur in varying amounts, but generally in small quantities.

The salts found in the underground and seepage waters are indicative of the salts found in the soils. In the analyses of seepage waters, both in the field and in the laboratory, bicarbonates and sulphates are shown

to be the principal salts found in the area. It would be expected that both the seepage waters and the soils would contain a large percentage of sulphates, on account of the large amount of gypsum found in the area. The presence of gypsum accounts for the absence of harmful amounts of carbonates, or black alkali, which is changed by chemical reaction with gypsum to the less harmful white alkali. It is safe to predict that on account of the large quantities of gypsum the farmers of the Laramie area need have no fear of any damage resulting from black alkali.

The following table contains results of the chemical analysis of alkali in soils:

Chemical analysis of alkali soil.

[Sample 9358, NE. cor. sec. 6, T. 15 N., R. 74 W., alkali crust from lake bottom.]

Constituents.	Per cent.	Constituents.	Per cent.
Ions:		Conventional combinations:	
Calcium (Ca)	1.05	Calcium sulphate ($CaSO_4$)	3.56
Magnesium (Mg)	.88	Magnesium sulphate ($MgSO_4$)	4.37
Sodium (Na)	29.84	Sodium sulphate (Na_2SO_4)	88.95
Potassium (K)	.27	Potassium chloride (KCl)	.52
Sulphuric acid (SO_4)	66.14	Sodium bicarbonate ($NaHCO_3$)	.09
Chlorine (Cl)	1.76	Sodium chloride (NaCl)	2.51
Bicarbonic acid (HCO_3)	.06	Per cent soluble	91.46

The alkali map accompanying this report shows the percentage of alkali found in the soils over the area. The percentages were determined by the electrolytic-bridge method and represent the mathematical mean for the first 6 feet of soil. The lands are classified into six grades—those containing from 0 to 0.20 per cent of alkali, from 0.20 to 0.40 per cent, from 0.40 to 0.60 per cent, from 0.60 to 1 per cent, from 1 to 3 per cent, and over 3 per cent.

On land which contains from 0 to 0.20 per cent of soluble salts all crops suitable to the soil and climate of the area do well, and no effects of the alkali can be noticed. The most productive lands of the area fall into this class.

On lands containing from 0.20 to 0.40 per cent of alkali mature plants grow without injury, but it is quite difficult to get the less resistant plants started, as many young seedlings are very susceptible to injury by alkali. If the land is heavily flooded before seeding this difficulty can be overcome in large measure. Alfalfa can be grown on such soils, but when the upper limit (0.40 per cent) is reached the effect of the alkali will be noticeable in diminished yields. Sugar beets and barley, being to some degree resistant, will do well on such soils, but beans will not thrive, as the young seedlings are too tender.

On soils which contain from 0.40 to 0.60 per cent of alkali only the most resistant alkali plants will grow. Beans can not be grown on

such soils, and alfalfa will not do well. If alfalfa is once established it will continue to grow, though the yield will be light. Sugar beets and barley will do fairly well on soils containing this amount of alkali. Such soils are especially adapted to salt grasses, greasewood, and various alkali plants.

On soils containing from 0.60 to 1 per cent of alkali the limit for cultivated crops is about reached. It is impossible to grow alfalfa with success on soils containing this proportion of soluble salts. The more alkali-resistant cultivated crops, such as sugar beets and barley, can be grown, but when the upper limit (1 per cent) is reached their culture is uncertain.

Where the soluble salt content of the soil is as high as from 1 to 3 per cent it is practically impossible to grow any of the cultivated crops and many of the salt grasses will not grow. Few weeds do well on such soils, greasewood and salt bushes comprising the principal vegetation.

Lands containing over 3 per cent of alkali are practically bare of vegetation. The salt content in this case is too high even for many of the more resistant alkali plants to grow. Salt bushes and greasewood are found on such soils, but the effect of the alkali is plainly visible on these plants.

As stated in the fore part of this chapter, the alkali map accompanying this report represents the mathematical mean of the percentage of alkali found in the first 6 feet of soil. The amount of alkali in each foot may vary considerably. In some cases the greatest amount may be in the first 3 feet, with a heavy surface accumulation; and, again, the first 3 feet may contain a very small percentage and the lower 3 feet may be highly impregnated. For these reasons the amount of soluble salts in the first foot may be more or it may be less than the amount shown on the map. But in studying the condition of the alkali in the soils and its effect upon vegetation the total amount for the 6 feet should be considered. As a rule many cultivated crops, especially alfalfa, send their roots to that depth in search of food and moisture, and in many cases the capillary movement in the soil extends through that depth.

In the western part of the area the surface accumulation of alkali is indicated by black hatching. The amount of alkali in the first foot is, however, very slight and the surface accumulation has little or no effect on vegetation. The alkali in this case is due to the nearness of the water table to the surface.

The distribution of alkali in soils varies considerably over the area, depending upon the position of the water table, the occurrence of seepage water, and the physical properties of the soil.

In the Redfield sandy loam the alkali usually occurs below the first 6 feet, leaving the soil practically free. In all tests made on this soil

where alkali occurred it generally increased with depth. The percentage of alkali in this soil varies from 0 to 3 per cent, but the higher percentage occurs only in local places. The soil of this type is of a loose, coarse sandy texture, and the water table is over 10 feet below the surface.

The amount of alkali found in the gypsum deposits varies from 0.20 to 3 per cent. The soil covering the gypsum is a loam and the greatest amount of soluble salt occurs in the first 2 feet, the second generally containing the higher percentage. It gradually decreases in amount with depth, the sixth foot rarely exceeding 0.40 per cent and in many cases being considerably less. The quantity found in the soil covering varies from 0.60 to 3 per cent. The water table was generally found within 10 feet of the surface.

The amount of alkali found in the Laurel sandy loam varies from 0 to over 3 per cent, depending upon the position of the water table. In the south central part of T. 15 N., R. 74 W., occurs an area with the largest proportion of alkali, over 3 per cent. The water table in this case lies between 6 and 10 feet from the surface. The soil is deep and heavy, and the alkali found in it is the result of seepage from the uplands. The alkali occurring in this soil is usually found in the first 2 to 4 feet, depending upon the depth of soil. The largest quantity generally occurs in the second foot, although in a number of cases the highest percentage occurs in the surface foot. The underlying subsoil of sand and gravel contains a very small amount of soluble salts.

Except where the soil is subject to seepage, the Laramie sandy loam does not contain a sufficient amount of alkali in the first 6 feet to affect cultivated plants. Under the Pioneer Canal, however, quite extensive areas of alkali occur as a result of seepage from the canal. The water table is, in most cases, within 6 feet of the surface, and very often within 3 feet. The alkali varies in amount from 0 to 1 per cent, with the heaviest accumulation usually in the first foot, the proportion decreasing with depth, until in the fifth and sixth feet a very small percentage is present.

The Billings clay contains, on the average, more alkali than any of the other soils of the area. The alkali in this soil comes from the shales from which the soil originates, and is well distributed throughout the entire 6-foot profile. In the northwest corner of sec. 17, T. 16 N., R. 74 W., the percentage of alkali averages over 3 per cent for the 6 feet. The first foot contains the highest amount, 3.40 per cent; the second, third, and fourth feet contain 3.19 per cent each, and the fifth and sixth feet contain 3.25 per cent each. In a 12-foot boring made in the basin in the northwest corner of T. 16 N., R. 74 W., the highest percentage of alkali was found in the fourth and fifth feet, averaging 2.01 per cent.

For the number of tests made in the soil the fourth foot contained on the average the highest percentage of alkali. In many cases, how-

ever, the content was greater in the surface foot, depending on the position of the water table.

The Laramie gravelly loam is practically free from alkali. Slight surface accumulations occur under the Pioneer Canal, but not in sufficient quantities to injure vegetation.

RECLAMATION OF ALKALI SOILS.

It seems to be the custom of the farmers of the Laramie area to use excessive quantities of water in irrigation, and to this must be ascribed much of the damage from alkali. Fields that at one time were very productive have become practically worthless from the rise of alkali salts, and the water table has been raised to within a few feet of the surface in many places. Besides the rise of alkali due to overirrigation a considerable damage results from seepage from the canals, and injury from this source still continues. If catch canals were constructed along the main canal where seepage is the worst, and if good drains were put in to carry away the surplus water used in irrigation, the rise of alkali in the soils would be checked and in time the land could be reclaimed. The fall toward the river in most cases is good, and on account of the loose texture of most of the soils the drains would not have to be put very close together. To accomplish the most good drains should be constructed diagonally across the direction of fall. Reclamation in most cases would be rapid and the cost would be comparatively little. Were it not for the injurious amount of alkali in the soils they would be very productive, and they are well worth the time, labor, and expense of reclamation.

In the western part of the area the ranchmen are not likely to have any serious trouble from the rise of alkali. Here the soils are of a very coarse texture and contain a large percentage of sand and gravel to a depth of several feet. This gives the soil excellent natural drainage and the salts are washed out as rapidly as they are formed. This fact emphasizes the importance of good drainage as a practical method of removing alkali from the soil.

In the lower lying areas, especially in old lake bottoms and basins, where there is no outlet and no possible way of washing the salts out of the soil, the land can not be reclaimed by the gravity method of drainage. These places will probably remain alkali lakes with the alkali continually increasing. The soil in these low places is heavy, being formed from the finest material from the uplands and from the underlying shales which occur over most of the area. It is fortunate that these basins are more local than general, for even if they can not be reclaimed, occupying only a small percentage of the area, they are of relatively little importance.

Generally speaking, the trouble in the area at present is due to an excessive amount of white alkali in the soils, and drainage is the only efficient method known for coping with this problem. While there

is some black alkali in the area, the quantity is so slight as to be negligible, and the presence of extensive deposits of gypsum warrants the belief that no fear need be entertained that this most toxic of salts will ever prove dangerous to the agriculture of the area. That the condition of the soil with respect to alkali salts can be permanently and economically improved has been amply shown by the demonstration experiments in alkali-land reclamation carried on by the Bureau of Soils at Fresno, Cal., Salt Lake City, Utah, and elsewhere in the West.

AGRICULTURAL METHODS.

The agricultural methods followed in the Laramie area differ but little from those of other areas where agriculture is just beginning to be developed. Most of the irrigated lands of the area are devoted to hay, which is used for winter feeding. The hay is cut during the latter part of July, or the fore part of August, and stacked in the fields.

Not much difficulty is experienced in bringing new land under cultivation. The soils are nearly free from vegetation, and all that is required is a good plowing and the construction of ditches for irrigating purposes. In bringing new land under cultivation it is usually first planted to potatoes, which do very well on the virgin soils. After one or two crops of potatoes have been harvested the land is put into wheat, oats, or barley. The grain is usually sown broadcast. The grain crops mature and are usually harvested about the middle of September. Practically no systematic rotation is practiced in the area, the land being planted year after year to such crops as the farmer wishes to grow, without regard to the needs of the soil.

The usual method of irrigation is by flooding, and considerable water is wasted, especially in irrigating the meadow lands. The canals are allowed to overflow and the water runs at will over the land. In the irrigation of cultivated crops greater care is exercised. Several ditches are constructed over the field, and the soils are quite evenly irrigated and little water is wasted. If more careful methods were generally followed there is no doubt that, even with the somewhat limited water supply at certain seasons of the year, considerably more land could be irrigated than at present.

AGRICULTURAL CONDITIONS.

The agriculture of the area is as yet but little developed, and it is only within recent years that farming has received any attention whatever. Stock raising has been the principal occupation of the area and the great profit that has been realized from stock has been the means of retarding agricultural development.

The majority of the farmers are in a very prosperous condition. The farms and ranches are, as a rule, free from indebtedness and the

people are all well off. Quite a number of wealthy ranchmen own large ranches in the area. The assessed valuation of all property in Albany County is $4,248,938.64. The total assessed valuation of lands and improvements is $1,141,955, and the rate of taxation is 27$\frac{3}{8}$ mills on the dollar.

The value of land depends, of course, upon its character, position, and water rights. The uplands, which are not susceptible of cultivation and which are used only for range purposes, can be bought for from 75 cents to $1 an acre. The better improved lands under irrigation bring from $20 to $30 an acre.

The farms and ranches are generally operated by the owners, and in very few cases is land rented. A number of the larger ranches are owned by companies, in which case either a stockholder in the company, or a competent foreman hired for the purpose, looks after the interests of the firm.

The size of farms and ranches varies considerably. Farms that are devoted to agriculture vary in size from 40 acres up to a quarter section, while the ranches in most cases are very large, varying in size from a section to several sections. The smaller ranches are usually under individual ownership; the larger ones are owned and managed by companies.

During the present season there was a great scarcity of farm labor, and many of the ranchmen were dependent on boys for harvesting the hay crop. As a rule, help is very scarce during the harvest season, which is about the only time in the year that help is in demand.

Ranchmen usually hire experienced men (cowboys) to look after their stock. These men are very proficient in their work, and as a rule receive good wages.

In that part of the area traversed by the Union Pacific Railroad the transportation facilities are good. This line runs through the area from north to south and connects it with eastern and western markets. The greatest trouble encountered is in getting the produce to the station from distant parts of the area. Ranchmen who live in the outer parts of the area have to haul their produce a distance of from 15 to 25 miles. The freight rates are quite high, and altogether the production of many crops in these more remote parts of the area is unprofitable. This has greatly retarded the agricultural development of the area, and very little farm produce is shipped out of Laramie, the supply during most seasons being insufficient to meet the demand of home trade.

Stockmen depend almost altogether on Eastern markets for selling their stock. Laramie affords an excellent shipping point, and stock is brought in from the country for miles around. Several carloads of horses, cattle, and sheep are shipped almost daily from this place.

Accessibility Statement

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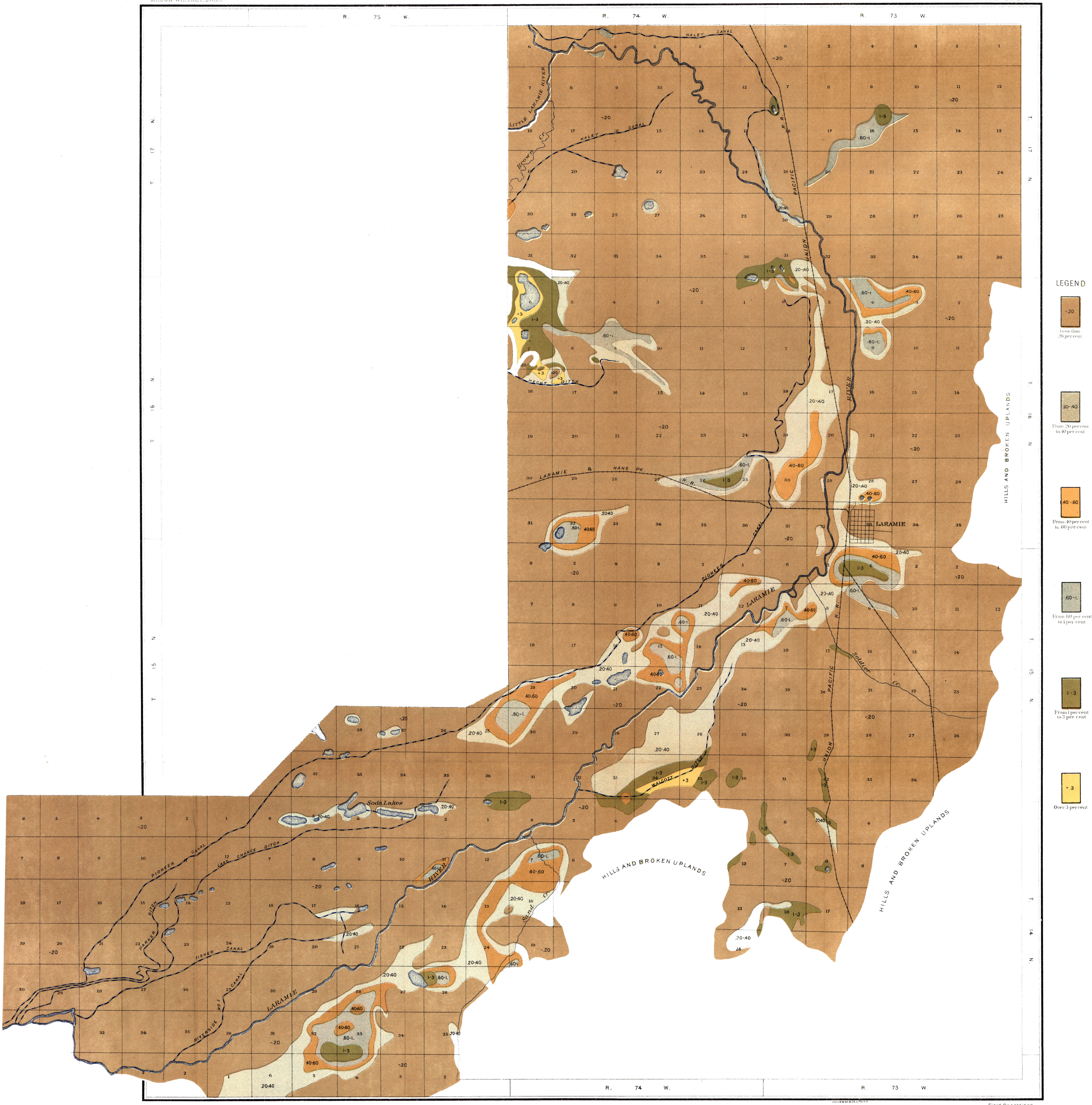
ALKALI MAP

WYOMING
LARAMIE SHEET



Alkali surveyed by
N. P. Neill and party
1903

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1903

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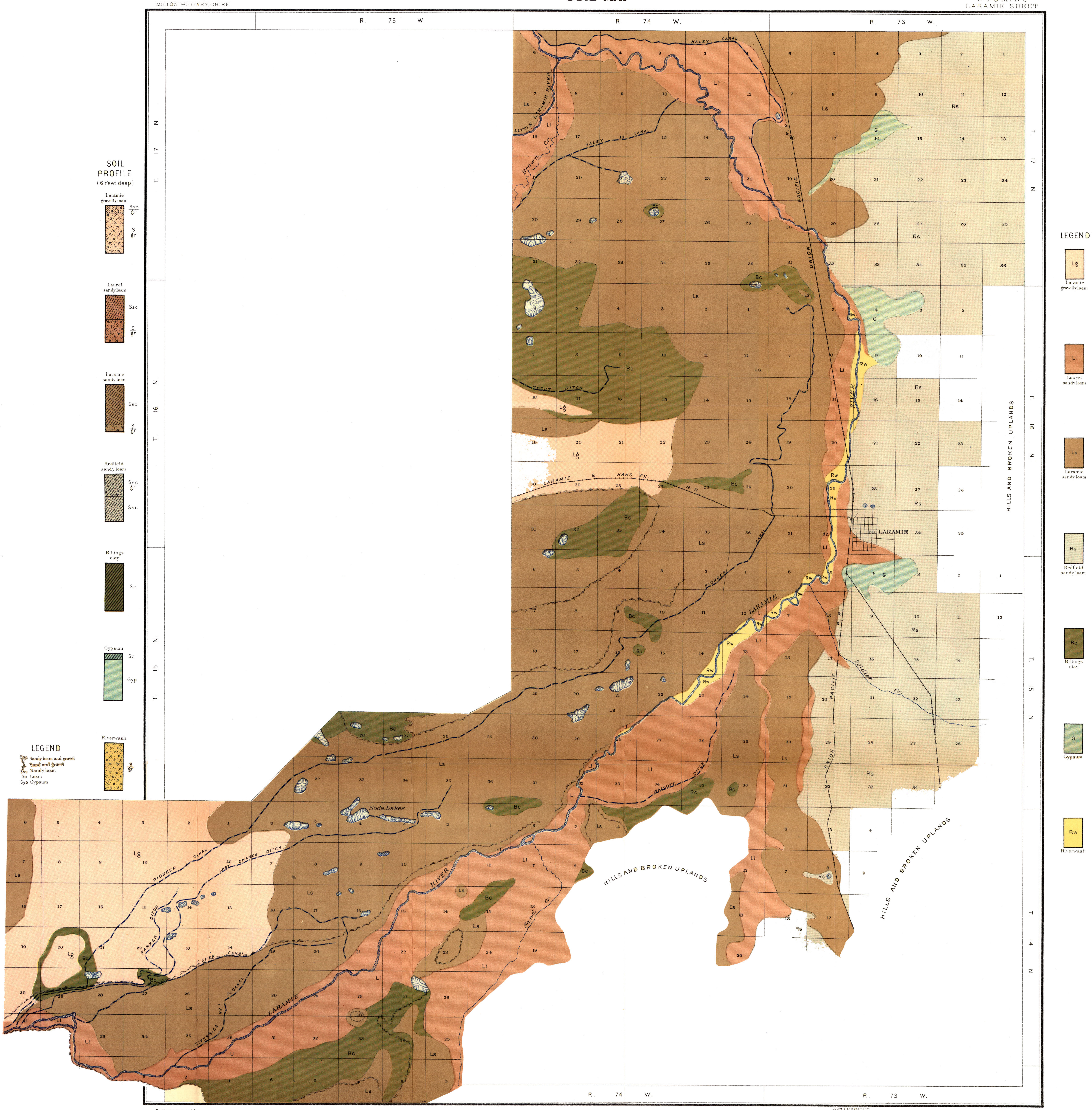
SOIL MAP

WYOMING
LARAMIE SHEET

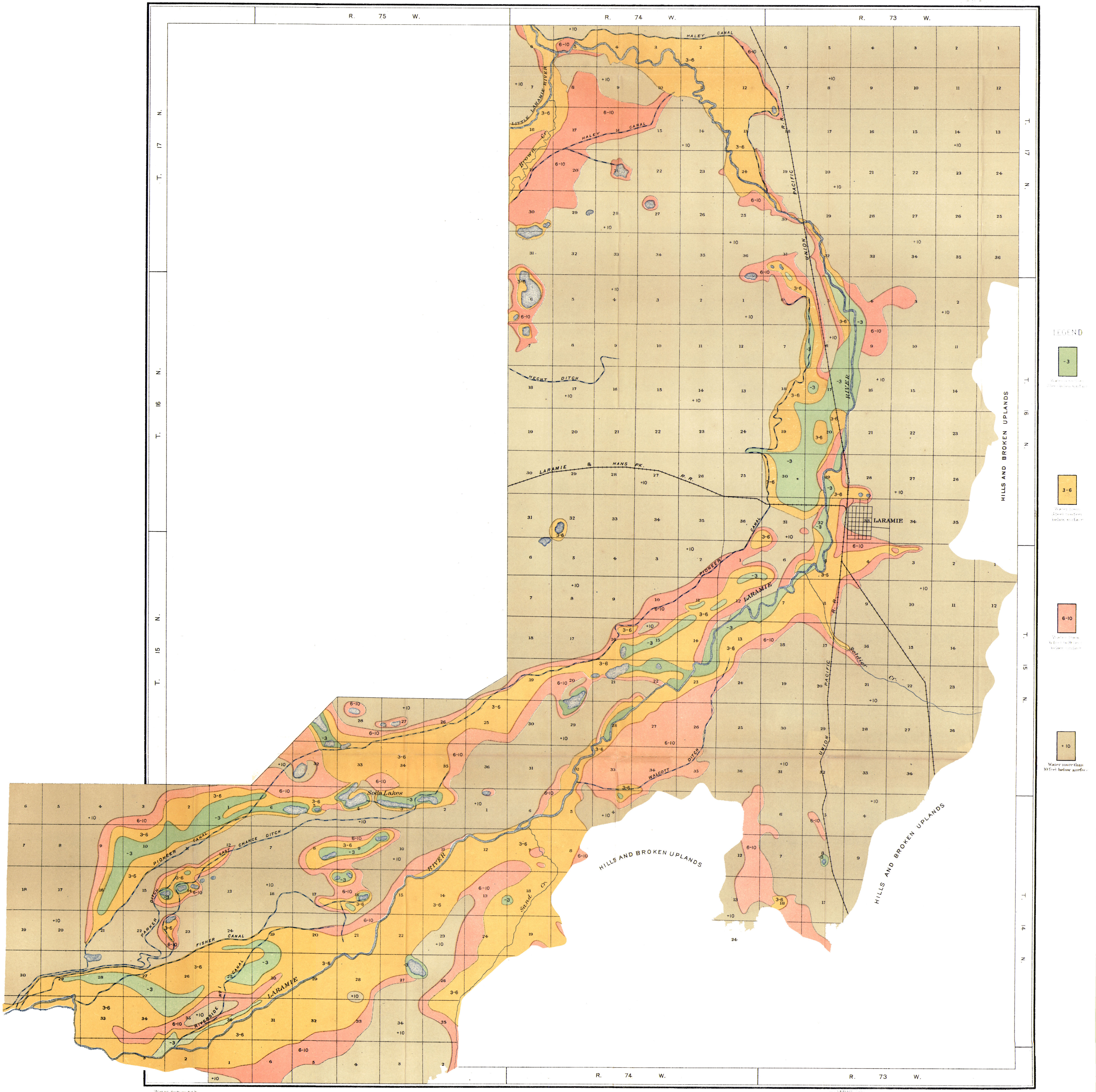


Soils surveyed by
N.P. Neill and party
1903

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1903

UNDERGROUND WATER MAP



Water surveyed by
N. P. Neill and party,
1903